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(54) Gas turbine engine control based on inlet pressure distortion

Regelung einer Gasturbine auf der Basis von Einlassdruckdistorsion

Contrôle d'un moteur à turbine à gaz basé sur la distortion de la pression à l'entrée

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GB-A- 2 191 606 GB-A- 2 248 885
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Description

This invention relates to gas turbine engines, in particular, gas turbine engine control based on inlet pressure distortion.

Future aircraft gas turbine engines must have the capability to successfully accommodate the increased steady-state and dynamic inlet pressure distortion that is encountered on high speed aircraft operating at supersonic speeds, and on aircraft with high maneuverability thrust vectoring. These distortion effects directly impact compressor stall margin, and future engine systems, which will be designed with less stall margin to reduce compression system weight. Reduced design stall margin is made practical by the newer adaptive engine control systems that are capable of maintaining adequate stall stability by adjusting the steady state and transient compression system component match points to instantaneous engine operating conditions. Inlet pressure distortion and inlet recovery are but factors--although very important--in establishing the instantaneous stability requirements. In a contemporary adaptive control system, these factors are not measured but are represented by non-adaptive model algorithms. The margins that are required to account for high pressure distortion operation reduces the potential benefit of the adaptive control concept during normal engine operation.

The relationship between compressor stall and inlet conditions is known. U.S. patent 5,165,844, for instance, also assigned to the assignee of this application, discusses some techniques to control compressor "stall margin", and may be considered representative of the state of the art dynamic, real-time techniques that control engine geometry with active components such as stators and variable exhaust nozzles.

Variations in pressure across and around the compressor inlet duct (radial and circumferential pressure variations) can be so uneven at times as to put substantial portions of the compressor in operating conditions at or below proper stall pressure ratios. U.S. patent 4,872,807, also assigned to the assignee of this application, considers a technique that measures inlet pressure at the compressor axis, but not inlet pressure distortion, as part of a scheme to control "engine geometry" with a control, to regulate stall margin levels. The patent describes a computation process, partially harnessed in this invention, by which the static pressure yields a dynamic pressure component based on the instantaneous engine operating conditions, namely N1, N2, T2 and PT2. That process only measures the pressure at one point--only at the engine center line axis at that.

To some degree, what is shown in U.S. patent 4,872,807 typifies conventional approaches premised on employing predetermined correlations of distortion intensity as a function of aircraft altitude and flight condition, engine airflow and inlet ramp position (on variable inlet equipped aircraft). In other words, they are prem-

ised on estimations of pressure distortion that can be encountered but are not premised on the actual pressure distortion.

Conventional jet engine knowledge recognizes that

- 5 there usually are variations in pressure across and around the inlet surface; in other words, an uneven pressure distribution. This can arise for many reasons, among them engine orientation and ambient airflow during different aircraft flight modes and ambient airflow
- 10 conditions. Depending upon the magnitude of variation in pressure from an average pressure and the location of these variations radially and circumferentially, an engine will experience variations in stall margin. Conventional measurements of these pressures during tests
- 15 have used total pressure sensors located at different (up to forty) locations in the inlet.

But for actual aircraft applications, total pressure sensors are not practical for reasons of safety and reliability. Extending into the airflow path, much like a pitot

- 20 tube used on aircraft to measure airspeed, a total pressure sensor is an obstruction directly in front the compressor blades, not only affecting airflow to some extent, but, creating a dangerous projectile that can break off if struck by debris, producing catastrophic engine damage.
- 25 The approach may have some appeal for experimental purposes but is unacceptable for actual aircraft applications for those safety reasons.

Several methods for computing total pressure measurements with distortion indices are in use in the

- 30 gas turbine industry, but only for experimental purposes since they are premised on total pressure measurements simply to determine experimental inlet pressure variations. One standard, often used to correlate measured pressure distribution to distortion levels, is the industry standard SAE ARP 1420. Though this standard is primarily intended for research purposes, where a large number of measurements are made (typically 40), it may be applicable to a reduced number of measurements. The technique is predicated on the relationships
- 35 between "total stall margin loss" and stall margin due to circumferential and radial pressure distortion. The total stall margin loss may be computed by interpolating stall margin loss from experimentally obtained circumferential and radial pressure distortions using flow obstructing devices such as screens and meshes with different areas in the inlet flow path.

A gas turbine engine and a method of its control having the features of the first parts of claims 1 and 6 is known from US-A-4 523 603 and GB-A-2 248 885.

- 50 An object of the invention is to provide a highly responsive static pressure sensor array and processing system for combined use in the calculation of inlet face distortion and in the recognition of stall precursors associated with near-stall operation.

An object of the invention is to use the quantitative intensity of the distortion components (steady and time varying; circumferential and radial) with adaptive engine models in representing the effects on inlet recovery,

component performance and stall line loss.

An object of the invention is to rely on system bandwidth to filter time varying disturbances into components that should be rejected by the control system and components that must be accommodated by stability margin. Recognition of stall precursors can identify near-stall operation to provide adaptive models of the basic compression system and provide instantaneous limiting for safety.

An object of the present invention is to provide an improved stall margin control in gas turbine engines by mapping total airflow into the engine based on static pressure measurements correlated to specific engine characteristics.

The solution to such problems is disclosed in claims 1 and 6.

According to one aspect of the invention, there is provided a gas turbine engine comprising a control for modifying engine airflow geometry as a function of engine operating conditions comprising signal processing means, characterized by means on a main air inlet to the compressor for providing a plurality of static pressure signals corresponding to the static pressure value at a plurality of inlet locations along inner and outer diameters of the inlet; and the signal processing means comprising means for converting each static pressure signal to a total pressure signal, for computing, from each total pressure signal, pressure variation values for radial and circumferential directions across the inlet between the inner and outer diameters, for producing a signal manifesting the pressure distortion level for the inlet by correlating said pressure variation values with stored values of pressure distortion for the inlet that are stored in the signal processor, and for providing a control signal to change engine airflow geometry as a function of a stall margin loss signal produced by correlating the signal manifesting pressure distortion to the engine using values for stall margin loss for the engine that are stored in the signal processor.

Preferably, multiple static pressure measurements are made in the inlet and converted to local instantaneous total pressures to determine the variation and thereby the total pressure distortion from which engine control is augmented to balance engine operation to the distortion pattern.

Preferably, from the total pressure measurements, circumferential and radial distortion are computed and then used to address stored data indicating a stall margin condition for the inlet. The stall margin indication is used to address a compressor airflow geometry correction for the particular engine to produce a signal that changes airflow to achieve a desired stall margin (reduce "stall margin loss" due to the total pressure distortion).

Time varying levels (oscillations and transients) in the total pressure serve as an indication (precursor) of a stall and, preferably, to initiate an immediate change in compressor airflow geometry.

Preferably, starting with the computed total pressure (P_t) for each sensor (computed from the static pressure) the average total pressure (P_{tavg}) for all the sensors is computed in real time by a signal processor producing a signal AV. The average total pressure (P_{IDavg}) of all the inner diameter (ID) sensors (around the cone) is computed along with the average (P_{ODavg}) of the total pressures for all of the outer diameter (OD) sensors (along the circumference of the inlet). The distortion in

- 5 the radial direction is determined from the difference between P_{ODavg} and P_{IDavg} divided by P_{tavg} . The circumferential distortion is determined from the difference between P_t (total pressure computed at each point) and the P_{tavg} divided by P_{tavg} , producing a distortion value for each OD sensor location, from which a map of overall circumferential distortion value is available. From that value, circumferential stall margin loss is determined by referencing stored data for the specific inlet. Using the stall margin loss and stored information on the engine
- 10 specifically correlating the relationship between stall margin loss and actual engine airflow (pressure ratio) a signal is produced to achieve a desired pressure ratio.
- 15

Among the advantages of the present invention, it provides superior stall margin control that is tailored to each engine through a somewhat "universal" inlet pressure sensing philosophy; that is, the same pressure sensor arrangement can be used on different types of engines. In any case, the sensors are non-obstructing.

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Another advantage of the invention is that it can use opto-pressure sensors for pressure sensing and can be incorporated into "FADECS" (full authority digital engine controls). The same approach may be taken to provide a map of inlet temperature across the inlet, also using flush sensors incorporating temperature probes.

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Still another advantage, the invention provides instantaneous measurement and recognition of the actual inlet distortion pattern. Distortion measurement improves accuracy, reduces analytical and flight development, accommodates rapidly occurring abnormal conditions such as exhaust ingestion, aircraft wakes, ground effects and inlet failure or damage. The invention also provides actual measurement of engine face pressure for inlet recovery calculation and optimization.

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An embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

FIG. 1 is a functional block diagram showing an aircraft gas turbine and a control and signal processing system for processing static pressure signals from a plurality of static pressure sensors around the inlet and around the inlet cone in an arrangement embodying the present invention.

FIG. 2 is a flow chart showing signal processing steps for carrying out the present invention using the signal processor shown in the system shown in FIG. 1.

FIG. 3 is a flow chart of a subroutine for computing pressure from a static pressure sensor using T_{T2} , P_s , $N1$ signals from the gas turbine engine.

FIG. 4 is a graph showing a typical map of radial pressure distortion when there is difference between radial and circumferential static pressure measurements of the type sensed according to the present invention.

FIG. 5 is a graph showing total circumferential pressure distortion around an inlet with circumferential pressure distortion.

When flow path pressure is measured at sites distributed around the outer and inner walls of an engine, as in the case of this invention, it may be done with flush or slightly protruding static ports (to pressure sensors). In the preferred embodiment there are typically six to eight sites on the outer wall, equally spaced apart (angularly) and three to four on the inner wall (engine nose). The pressure measurements are converted using basic equations such as:

Static to Total Pressure Conversion

$$\text{Equation 1} \quad M = [(2/\gamma - 1)(1 - (P_t / P_s)^k)]^{1/(\gamma - 1)}$$

where:

P_t = total pressure

P_s = static pressure

M = Mach number (flow)

C_p = position error

$k = \gamma - 1/\gamma$

This shows that for a particular fan (compressor) the solution to the first relationship can be represented as a tabular conversion function in terms of inlet corrected mass flow:

$$\text{Equation 2} \quad P_t/P_s = f(\text{inlet corrected mass flow})$$

With these relationships, total pressure is calculated for each measurement point (static sensor position) by multiplying the static pressure by the conversion function obtained at the site of each static pressure sensor.

Referring first to FIG. 1, the internal components of a gas turbine engine 10 have not been shown. Those components are known, as shown, for example, in U.S. patent 4,414,807, which also shows engine operating signals (in common nomenclature) N_1 , W_f , T_{T2} which are used in a computation made with the invention shown in FIG. 3, where the total pressure is P_t . The engine is assumed to have mechanisms to vary its airflow geometry, such as a variable area exhaust nozzle 10.1 and a stator control (not shown) operable by a stator control signal ST . The signal $NZ1$ controls the nozzle area. An electronic control 12 is connected to a power lever 14 that provides a PWR signal to the control 12, which, among other things, controls fuel flow W_f to the engine. The control 12 is "computer based"; that is it has a "central processing unit" or signal processor (CPU)

that is programmed to receive the indicated signals, address a memory unit MEM and control engine operation. This is an oversimplification of a so called "digital electronic engine control" because the assumption is that

5 the fundamentals of such controls are well known in the art, in as much as those controls are in wide use. The invention resides in using such a control and special sensors (flush static pressure sensors) to give a gas turbine engine a special operating quality. The control 12 is assumed to have an input/output section 12.1 through which it interacts with the engine and its subsystems, such as the stator control or the nozzle area control. Subsystem 12.2 represents a common fuel control section of the control.

10 Directing attention to the front end or inlet 10.2 of the engine, the presence of eight "circumferential" static pressure sensors 16 or transducers should be observed. These are located on the inside of the inlet, preferably just in front of the fan. Each sensor provides a signal PC to the control 12 over one of the lines 12.4. Radially inward from the sensors 16, are four similar static pressure transducers 18. These are located around the nose, just before the fan. Each sensor 18 provides a signal PR of one of the lines 12.5 to the control 12. Considering the inlet surface area, it will be noted that a sensor 18 is approximately angularly equidistant from a sensor 16.

15 Before considering the way that the control uses the signals (of static pressure) from the sensors 16 and 18 with the aid of the signal flow charts in FIGS. 2 and 3, attention should be directed to the graphs in FIGS. 4 and 5. Graph 4 shows that as the radius (from a sensor 18) increases it can be assumed that the pressure distortion will increase linearly. Thus, starting with a pressure measurement at a sensor 18, a radially map of pressure along an imaginary radial map line 18.1 would follow the pattern of FIG. 4. On the other hand, FIG. 5 provides a different plot of pressure around the inlet circumference; that is, along the imaginary line 16.1 along which the sensors 16 are placed. This map shows pressures that are above and below average demonstrating a distorted pressure pattern. The magnitude of circumferential pressure distortion is manifested in the map in FIG. 5 and may be computed from the total area of the map.

20 Applying this to FIG. 2, which is an exemplary signal processing scheme for carrying out the invention, the process begins with step S1, when the pressure signals (PC and PR) are read from the sensors. At step S2, the total pressure for each sensor is calculated using the total pressure P_t computation subroutine shown as steps S20-S26 in FIG. 3, which uses standard engine nomenclature to explain how to produce, at step S26, the value P_t from each static pressure signal. There "PS" means either PC or PR.

25 At step S3 in FIG. 2, the radial and circumferential pressure distortions are calculated in this way starting with the value of P_t for each sensor. All the values of P_t

are averaged to produce P_{tavg} . Then, the average of P_t for all the OD sensors 16 is calculated (P_{todavg}) and, likewise, the average for all the sensors 18 is calculated (P_{tidavg}). Radial pressure distortion is calculated by:

$$\text{Equation 3} \quad \text{Radial distortion} = (P_{todavg} - P_{tidavg})/P_{tavg}$$

Circumferential distortion, however, is calculated somewhat differently. The first step is to calculate the difference between the total pressure at each sensor 16 and the P_{tavg} . Then, that difference is divided by P_{tavg} , producing a ratio with a magnitude indicative of the total pressure variation from the average for each sensor 16. Thus, eight values of data points will be produced if eight sensors are used, as shown in FIG. 1. As will be explained below with reference to step S6, these data points are correlated to experimentally obtained data points for the inlet to determine the stall margin loss. The radial distortion value is likewise correlated.

However, before moving to step S6, the routine tests the peak to peak (P-P) variations in static pressure of one or more of the sensors to produce a signal XP. In step S5, a stall precursor flag (Flag 1) is set if the value of XP exceeds a reference value, indicating that a stall is imminent. A test is made at step S5.1 for Flag 1 and an affirmative answer moves the routine immediately to step S9, which initiates a stall prevention/recovery pattern, e.g. immediately opening the exhaust nozzle on the engine or opening the stator vanes.

Assuming a negative answer at step S5.1, the routine progresses to step S6. There, radial and circumferential pressure distortion data for the inlet are referenced, e.g. from a look-up table in the MEM, to determine the stall margin loss for the inlet. Engine model data is read at step S7, a step that correlates the stall margin loss to the compressor characteristics and N2, causing, in step S8, the production of a control pattern for the engine, which is executed in step S10. That control pattern may involve, depending upon the engine characteristics, varying bleed, stator deflection or exhaust nozzle area.

The routine in FIG. 2 can, of course, be entered and run many times per second depending upon the main program. Ideally, pressure sampling in step S1 should be done at a rate that bandwidth limits pressure changes to avoid unnecessary aberrations, for instance at 1000 Hz, which would have a frequency response of 200 Hz, sufficient for the data that is monitored.

While pressure has been used, temperature may also be plotted and its distortion across the inlet also mapped and compared to generate a stall precursor signal that causes geometry augmentation if the error satisfies the distortion error for the particular engine. In this regard, it should be considered that the sensors in the inlet are "engine neutral": the data that they produce is

compared to data for the engine and data computed based on engine operation to diagnose the distortion pattern's severity for the engine and to command a geometry change if required for the engine. One type of sensor that may be used, because of its high response, light weight and EMI immunity, is the model P 104 by MetriCor.

10 Claims

1. A gas turbine engine (10) comprising a control for modifying engine airflow geometry as a function of engine operating conditions comprising signal processing means, characterized by:

means (16,18) on a main air inlet (10.2) to the compressor for providing a plurality of static pressure signals corresponding to the static pressure value at a plurality of inlet locations along inner and outer diameters of the inlet; and the signal processing means (12) comprising means for converting each static pressure signal to a total pressure signal, for computing, from each total pressure signal, pressure variation values for radial and circumferential directions across the inlet between the inner and outer diameters, for producing a signal manifesting the pressure distortion level for the inlet by correlating said pressure variation values with stored values of pressure distortion for the inlet that are stored in the signal processor, and for providing a control signal to change engine airflow geometry as a function of a stall margin loss signal produced by correlating the signal manifesting pressure distortion to the engine using values for stall margin loss for the engine that are stored in the signal processor.

2. A gas turbine engine according to claim 1, further characterized in that:

the signal processing means (12) comprises means for providing an AV signal manifesting the average of total pressure for the pressure sensors, for providing an OD signal manifesting the average of total pressure for each sensor along the inlet outer diameter, for providing an ID signal manifesting the average total pressure of each sensor along the inlet inner diameter, for providing a radial pressure distortion signal with a magnitude proportional to the difference between the OD and ID signals divided by the AV signal.

3. A gas turbine engine according to claim 1 or 2, further characterized in that:

the signal processing means (12) comprises means for providing a circumferential pressure distortion signal manifesting the difference between

the AV signal and the total pressure computed for each outer diameter sensor divided by the AV signal.

4. A gas turbine engine according to any preceding claim, further characterized in that:
the signal processing means (12) comprises means for providing a stall precursor signal in response to time varying changes in at least one of the static pressure signals and for providing a stall control signal to modify engine airflow geometry in response to the stall precursor signal to increase compressor stall margin. 5

5. A gas turbine engine according to claim 4, further characterized in that the time varying changes are peak to peak changes. 15

6. A method of controlling a gas turbine engine (10) by means of modifying engine airflow geometry as a function of engine operating conditions, comprising the steps of:
providing a plurality of static pressure signals corresponding to the static pressure value at a plurality of inlet locations along inner and outer diameters of a main air inlet to the compressor; converting each static pressure signal to a total pressure signal; 20
computing from each total pressure signal pressure variation values for radial and circumferential directions across the inlet between the inner and outer diameters; producing a signal manifesting the pressure distortion level for the inlet by correlating said pressure variation values with stored values of pressure distortion for the inlet; and providing a control signal to change engine airflow geometry as a function of a stall margin loss signal produced by correlating the signal manifesting pressure distortion to the engine using stored values for stall margin loss for the engine 25

um den Innendurchmesser und den Außen- durchmesser des Einlaufs entsprechen; und wobei die Signalverarbeitungseinrichtung (12) eine Einrichtung aufweist zum Umwandeln jedes Signals für statischen Druck in ein Gesamtdrucksignal, zum Berechnen von Druckänderungswerten für die Radialrichtung und die Umfangsrichtung über den Einlauf zwischen dem Innendurchmesser und dem Außendurchmesser aus jedem Gesamtdrucksignal, zum Erzeugen eines Signals, das das Druckverzerrungsniveau für den Einlauf manifestiert, durch Korrelieren der Druckänderungswerte mit gespeicherten Werten der Druckverzerrung für den Einlauf, die in der Signalverarbeitungseinrichtung gespeichert sind, und zum Bereitstellen eines Regelsignals, um die Geometrie der Triebwerksluftströmung als eine Funktion eines Signals des Verlusts des Strömungsabrißspielraums zu ändern, das durch Korrelieren des Signals, das die Druckverzerrung manifestiert, mit den Triebwerksbetriebswerten für den Verlust des Strömungsabrißspielraums für das Triebwerk, die in der Signalverarbeitungseinrichtung gespeichert sind, erzeugt wird. 30

2. Gasturbinentriebwerk nach Anspruch 1, ferner dadurch gekennzeichnet, daß die Signalverarbeitungseinrichtung (12) eine Einrichtung aufweist zum Bereitstellen eines AV-Signals, das den Mittelwert für den Gesamtdruck für die Drucksensoren manifestiert, zum Bereitstellen eines OD-Signals, das den Mittelwert des Gesamtdrucks für jeden Sensor um den Außendurchmesser des Einlaufs manifestiert, zum Bereitstellen eines ID-Signals, das den Mittelwert des Gesamtdrucks für jeden Sensor um den Innendurchmesser des Einlaufs manifestiert, und zum Bereitstellen eines Signals der radialen Druckverzerrung mit einer Größe, die proportional ist zu der Differenz zwischen dem OD-Signal und dem ID-Signal geteilt durch das AV-Signal. 35

3. Gasturbinentriebwerk nach Anspruch 1 oder 2, ferner dadurch gekennzeichnet, daß die Signalverarbeitungseinrichtung (12) eine Einrichtung zum Bereitstellen eines Signals der umfangsmäßigen Druckverzerrung aufweist, das die Differenz zwischen dem AV-Signal und dem für jeden Sensor des Außendurchmessers berechneten Gesamtdruck geteilt durch das AV-Signal manifestiert. 40

4. Gasturbinentriebwerk nach einem der vorangehenden Ansprüche, ferner dadurch gekennzeichnet, daß die Signalverarbeitungseinrichtung (12) eine Einrichtung zum Bereitstellen eines Strömungsabriß-Vorläufersignals in Reaktion auf sich mit der Zeit verändemde Änderungen bei mindestens einem 45

Patentansprüche

1. Gasturbinentriebwerk (10) aufweisend eine Regelung zum Modifizieren der Geometrie der Triebwerksluftströmung als eine Funktion der Betriebszustände des Triebwerks, aufweisend eine Signalverarbeitungseinrichtung, gekennzeichnet durch:
eine Einrichtung (16, 18) an einem Hauptlufteinlauf (10.2) zu dem Verdichter zum Bereitstellen einer Mehrzahl von Signalen für statischen Druck, die dem Wert des statischen Drucks an einer Mehrzahl von Einlaufstellen 50

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der Signale für statischen Druck und zum Bereitstellen eines Strömungsabriß-Regelsignals aufweist, um die Geometrie der Triebwerksströmung in Reaktion auf das Strömungsabriß-Vorläufersignal zu modifizieren, um den Strömungsabrißspielraum des Verdichters zu erhöhen.

5. Gasturbinentriebwirk nach Anspruch 4, ferner dadurch gekennzeichnet, daß die sich mit der Zeit verändernden Änderungen von Spitzenwert zu Spitzenwert sind.

10. Verfahren zum Regeln eines Gasturbinentriebwirk (10) durch Modifizieren der Geometrie der Triebwerksluftströmung als Funktion der Betriebszustände des Triebwerks, aufweisend die folgenden Schritte:

Bereitstellen einer Mehrzahl von Signalen für statischen Druck, die den Werten des statischen Drucks an einer Mehrzahl von Einlaufstellen um einen Innendurchmesser und einen Außendurchmesser eines Hauptluft einlaufs zu dem Verdichter entsprechen;

20. Umwandeln jedes Signals für statischen Druck in ein Gesamtdrucksignal;

Berechnen von Druckänderungswerten aus jedem Gesamtdrucksignal für die radiale Richtung und die Umfangsrichtung über den Einlauf zwischen dem Innendurchmesser und dem Außendurchmesser;

30. Erzeugen eines Signals, das das Druckverzerrungsniveau für den Einlauf manifestiert, durch Korrelieren der Druckänderungswerte mit gespeicherten Werten der Druckverzerrung für den Einlauf; und

35. Bereitstellen eines Regelsignals, um die Geometrie der Triebwerksluftströmung als eine Funktion eines Signals des Verlusts des Strömungsabrißspielraums zu ändern, durch Korrelieren des die Druckverzerrung manifestierenden Signals mit gespeicherten Triebwerksbetriebswerten für den Verlust des Strömungsabrißspielraums für das Triebwerk.

40. Bereitstellen eines Regelsignals, um die Geometrie der Triebwerksluftströmung als eine Funktion eines Signals des Verlusts des Strömungsabrißspielraums zu ändern, durch Korrelieren des die Druckverzerrung manifestierenden Signals mit gespeicherten Triebwerksbetriebswerten für den Verlust des Strömungsabrißspielraums für das Triebwerk.

45. un moyen (16,18) sur une admission d'air principale 10.2) du compresseur permettant de fournir une pluralité de signaux de pression statique correspondant à la valeur de la pression statique à une pluralité d'emplacements d'admission situés le long des diamètres intérieur et extérieur de l'admission ; et le moyen de traitement de signal (12) comprenant un moyen permettant de convertir chaque signal de pression statique en un signal de pression totale, permettant de calculer, à partir de chaque signal de pression totale, les valeurs de variation de la pression pour le sens radial et sur la circonférence de l'admission entre les diamètres intérieur et extérieur, permettant de produire un signal révélant le niveau de la distorsion de la pression à l'admission en mettant en relation lesdites valeurs de variation de la pression avec les valeurs mémorisées de la distorsion de la pression à l'admission qui sont mémorisées dans le processeur de signal, et permettant de fournir un signal de commande afin de changer la géométrie du courant d'air du moteur en fonction du signal de perte de marge de calage produit par la mise en relation du signal révélant la distorsion de la pression et le moteur en utilisant les valeurs de perte de marge de calage pour le moteur qui sont mémorisées dans le processeur de signal.

50. 2. Moteur à turbine à gaz selon la revendication 1, caractérisé en outre par : le moyen de traitement de signal (12) qui comprend un moyen permettant de fournir un signal AV révélant la moyenne de la pression totale pour les détecteurs de pression, permettant de fournir un signal OD révélant la moyenne de la pression totale pour chaque détecteur le long du diamètre extérieur de l'admission, permettant de fournir un signal ID révélant la moyenne de la pression totale pour chaque détecteur le long du diamètre intérieur de l'admission, permettant de fournir un signal de distorsion de la pression dans le sens radial, dont l'amplitude est proportionnelle à la différence entre le signal OD et le signal ID divisés par le signal AV.

55. 3. Moteur à turbine à gaz selon la revendication 1 ou 2, caractérisé en outre en ce que : le moyen de traitement de signal (12) comprend un moyen permettant de fournir un signal de distorsion de la pression sur la circonférence révélant la différence entre le signal AV et la pression totale calculée pour chaque détecteur de diamètre extérieur divisé par le signal AV.

4. Moteur à turbine à gaz selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que :

Revendications

- Moteur à turbine à gaz (10) comprenant une commande permettant de modifier la géométrie du courant d'air du moteur en fonction des conditions de fonctionnement du moteur, comprenant un moyen de traitement de signal, caractérisé par :

le moyen de traitement de signal (12) comprend un moyen permettant de fournir un signal précurseur de calage en réponse à des changements variant dans le temps d'au moins un des signaux de pression statique et permettant de fournir un signal de commande de calage afin de modifier la géométrie de courant d'air du moteur en réponse au signal précurseur de calage afin d'augmenter la marge de calage du compresseur.

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5. Moteur à turbine à gaz selon la revendication 4, caractérisé en outre en ce que les changements variant dans le temps sont des changements de crête à crête.

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6. Procédé de commande d'un moteur à turbine à gaz (10) au moyen de la modification de la géométrie de courant d'air du moteur en fonction des conditions de fonctionnement du moteur, comprenant les étapes suivantes :

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fourniture d'une pluralité de signaux de pression statique correspondant à la valeur de la pression statique à une pluralité d'emplacements d'admission le long des diamètres intérieur et extérieur d'une admission d'air principale du compresseur ;

25

conversion de chaque signal de pression statique en un signal de pression totale ; calcul, à partir de chaque signal de pression totale, des valeurs de variations de la pression dans le sens radial et sur la circonférence de l'admission, entre les diamètres intérieur et extérieur ;

30

production d'un signal révélant le niveau de distorsion de la pression pour l'admission en mettant en relation lesdites valeurs de variation de la pression avec les valeurs mémorisées de la distorsion de la pression à l'admission ; et fourniture d'un signal de commande afin de changer la géométrie de courant d'air du moteur en fonction d'un signal de perte de marge de calage en mettant en relation le signal révélant la distorsion de la pression et le moteur en utilisant les valeurs mémorisées pour la perte

35

de marge de calage pour le moteur.

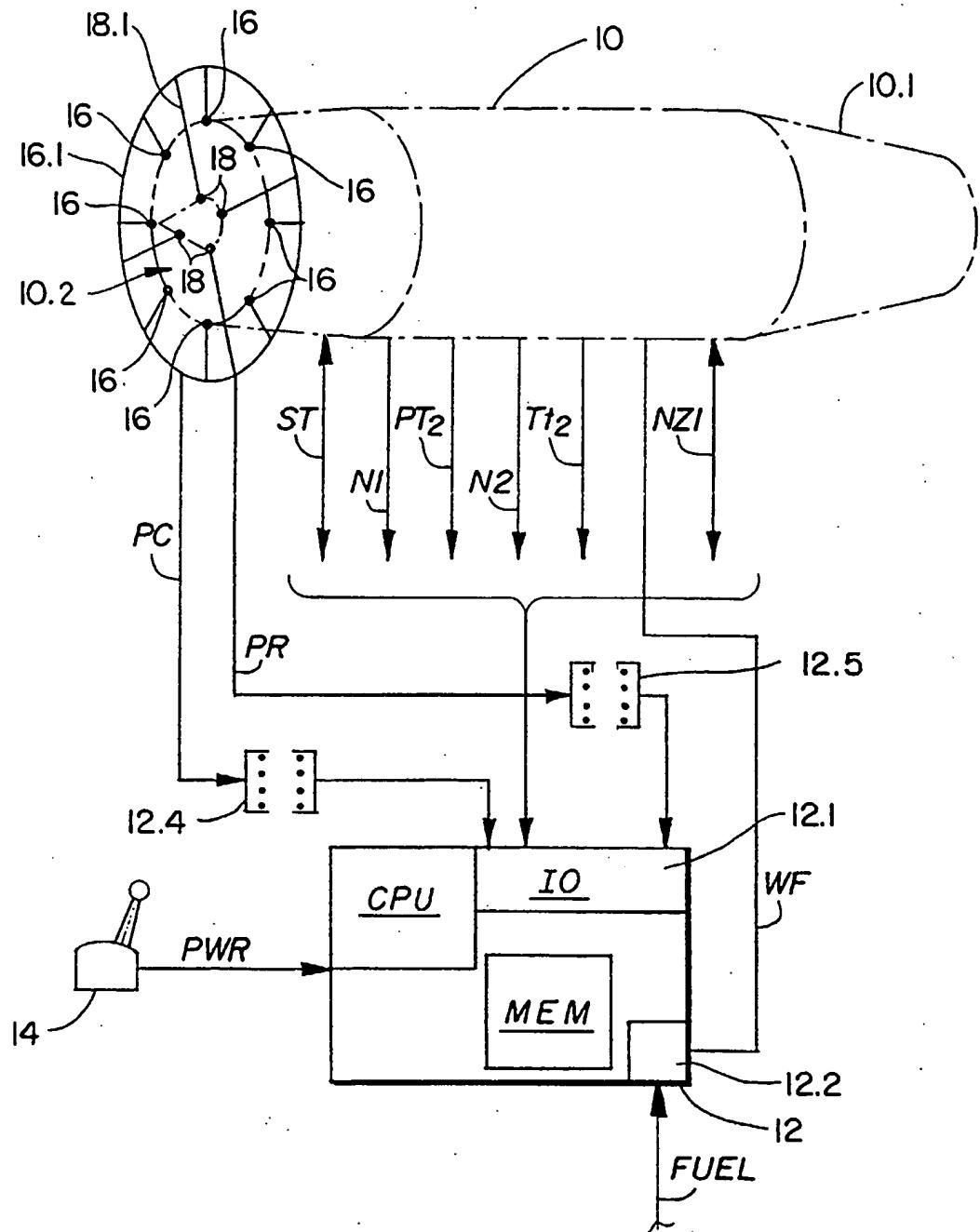
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50

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FIG. 1



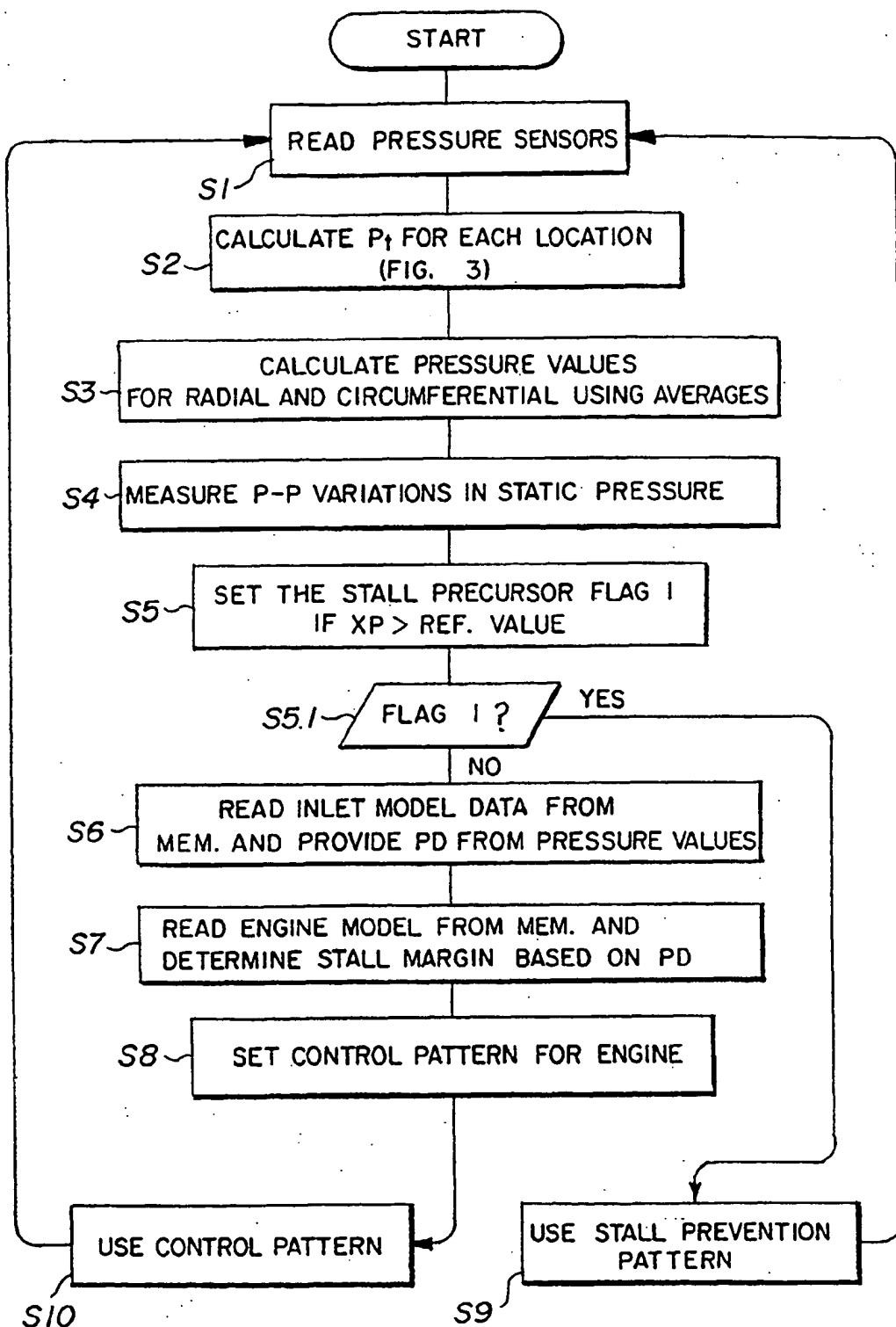


FIG. 2

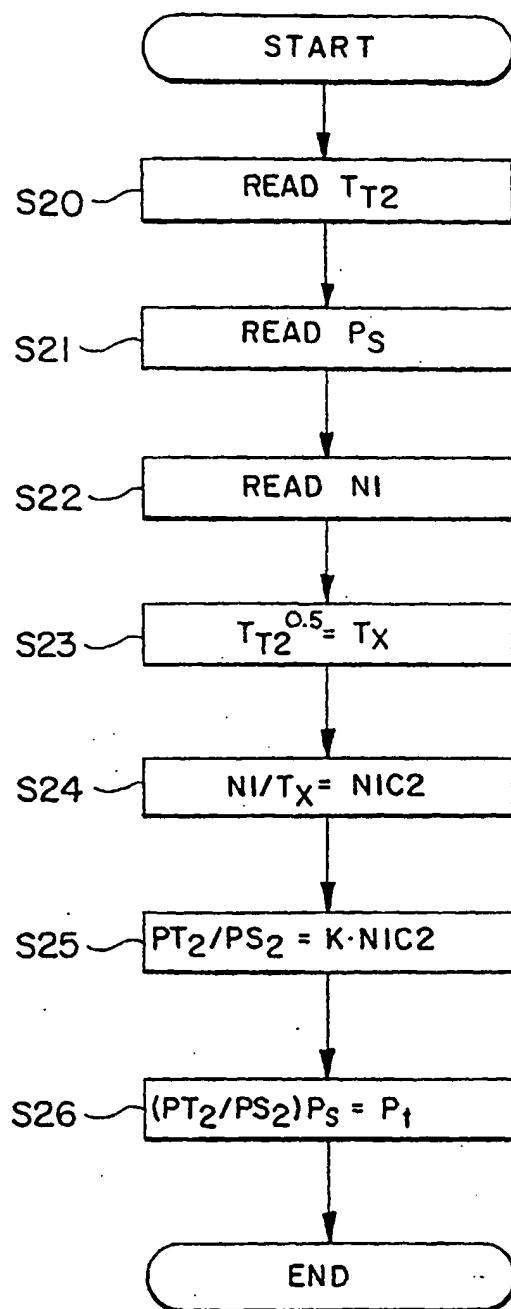


FIG. 3

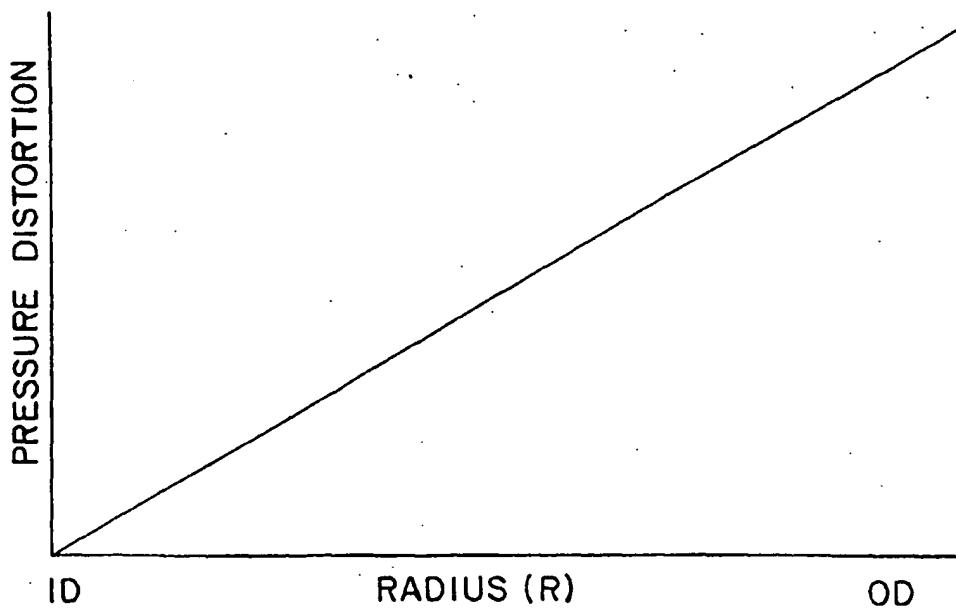


FIG. 4

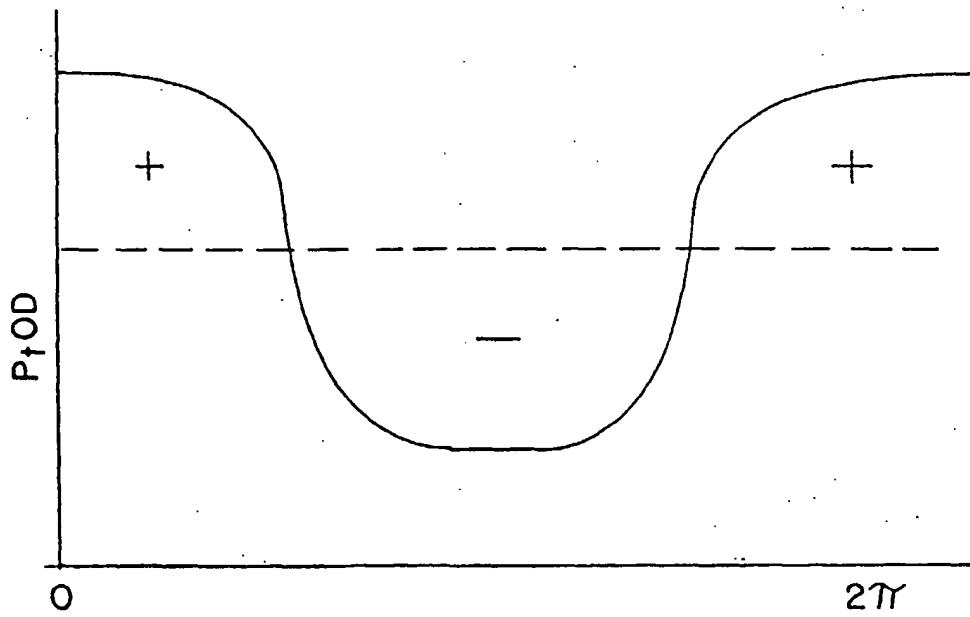


FIG. 5